

Technical Memorandum



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Subject: Stormwater Ordinance Review for Clark County, WA
Project No.: 14505

Executive Summary

Clark County is revising their stormwater and erosion control ordinance to meet the requirements outlined in their recently-issued NPDES permit. To assist in this endeavor, Otak has reviewed ordinances from several Western Washington jurisdictions to see how they have implemented provisions of the NPDES permit or Department of Ecology's Stormwater Management Manual for Western Washington, specifically in regard to thresholds for implementing minimum requirements, revisions to the permit's minimum requirements, Low Impact Development (LID), and conveyance standards. The jurisdictions reviewed are King County, Snohomish County, Washington Department of Transportation (minimum requirements only), City of Olympia, City of Tacoma, City of Bellingham, City of Portland (LID only), and Clean Water Services (conveyance only).

In regards to NPDES thresholds and minimum requirements, the cities of Bellingham, Olympia and Tacoma have adopted the Permit's minimum requirements verbatim. King County's Surface Water Design Manual has their own requirements which do not show a direct correlation with the permit's minimum requirements. Snohomish County does not have a stormwater ordinance which parallels the permit conditions, but we understand that they are in the process of preparing a new guidance manual and ordinance.

Each jurisdiction has taken steps to incorporate and address the permit requirements in regard to the inclusion of Low Impact Development (LID) techniques. Many of the jurisdictions, including the Department of Ecology, reference the *Low Impact Development Technical Guidance Manual for Puget Sound (2005)*, while others such as King County, and the City of Portland, have developed their own LID guidance manuals.

Conveyance requirements vary among the jurisdictions. The biggest difference in the approaches is that some jurisdictions, such as King County, require that a hydraulic grade line be calculated using backwater calculations. Other jurisdictions require only that the systems not overtop under uniform flow conditions and do not consider tailwater levels at the lower end of a ditch or pipe system.

Introduction

This technical memorandum summarizes the findings of an ordinance review of jurisdictions in Western Washington and Oregon to see how they have implemented changes related to NPDES MS4 permits. The jurisdictions reviewed for this memorandum include King County, City of Tacoma, City of Olympia, City of Bellingham, Snohomish County, Washington State Department of Transportation (WSDOT), City of Portland (LID only), and Clean Water Services (Conveyance only). Otak has looked at the ordinances and design manuals for each of the jurisdictions to see how they've addressed the following:

- Conformance to Minimum Requirements of the Phase I Municipal Separate Storm Sewer system (MS4) Permit
- Thresholds for implementing the minimum requirements
- How these jurisdictions are implementing Low Impact Development
- Methods For Computing Conveyance Capacities

This technical memorandum is broken down in sections for each topic listed above, with the different jurisdiction's approach described in each section.

Conformance to Minimum Requirements

The MS4 permit lists nine minimum requirements which permittees must implement in their stormwater ordinance. Each minimum requirement is listed below.

#1 --- Preparation of Stormwater Site Plans per Chapter 3 of Volume I Ecology Manual (2005)

#2 --- Construction Stormwater Pollution Prevention Plan (SWPPP)

#3 --- Source Control of Pollution in accordance with Volume IV of Ecology Manual (2005)

#4 --- Preservation of Natural Drainage Systems and Outfalls

#5 --- Onsite Stormwater Management to infiltrate, disperse and retain stormwater runoff onsite to the maximum extent feasible without causing flooding or erosion impacts

#6 --- Runoff Treatment

#7 --- Flow Control

#8 --- Wetlands Protection

#9 --- Operations and Maintenance

Adjustments to the Minimum Requirements may be granted provided that a written finding of fact is prepared that shows how the adjustments are equivalent to the minimum requirement being replaced. Objectives of safety, function, environmental protection, and facility maintenance need to be met.

Extra ---Optional Approach

In addition to the minimum requirements, Basin and Watershed Planning is also a recommended activity. Although not a minimum requirement in the permit, it is listed as Minimum Requirement #9 in the Ecology Manual and in ordinances of most other jurisdictions. It may be used to tailor minimum requirements #6, #7, and #8 to a watershed basin. (Note that most ordinances were prepared before the issuance of the NPDES permit in early 2007.) If used as such, the basin plan must:

- make certain that all ordinances or regulations called for by the plan are in effect,
- be formally adopted by all jurisdictions with responsibilities under the plan, and
- be reviewed and approved by the Department of Ecology.

Table 1 lists the requirements and summarizes our assessment of how several jurisdictions have adopted the minimum requirements. All of the ordinances have been prepared prior to the issuance of the 2007 permit and the Department of Ecology's 2005 Stormwater Management Manual for Western Washington (Ecology Manual).

Approaches to Satisfying Permit's Minimum Requirements

Minimum Requirement No.	Requirement in Permit	King County Surface Water Design Manual, 2005	City of Olympia Stormwater Manual	City of Tacoma 2003 Surface Water Management Manual	City of Bellingham Municipal Code 14.42.060 - Approval Standards 1995	Snohomish County Various Documents	Washington State Department of Transportation 2006 Highway Runoff Manual
1	Preparation of Stormwater Site Plans	No minimum requirement listed; 2.3.1.1 requires Technical Information Report (TIR)	Chapter 2, Same as permit	3.5.1 Same as permit	14.42.060.F.1 Same as permit	No unique list of requirements.	3-3.1 Same as permit
2	Construction Stormwater Pollution Prevention (SWPP)	No minimum requirement listed; CSWPP included in 2.1.2 - Plans required for drainage review	Chapter 2, Same as permit	3.5.2 Same as permit	14.42.060.F.2 Same as permit	No unique list of requirements.	3-3.2 Same as permit
3	Source Control of Pollution	No minimum requirement listed; Special requirement #4 - Source Control	Chapter 2, Same as permit	3.5.3 Same as permit	14.42.060.F.3 Same as permit	No unique list of requirements.	3-3.3 Same as permit
4	Preservation of Natural Drainage Systems and Outfalls	1.2.1 Core Req. #1 - Discharge at natural location	Chapter 2, Same as permit	3.5.4 Same as permit	14.42.060.F.4 Same as permit	No unique list of requirements.	3-3.4 Same as permit
5	On-Site Stormwater Management	No specific requirement; generally encourages on-site facilities. Core Requirement No. 3 specifies on-site detention.	Chapter 2, Same as permit	3.5.5 Same as permit	14.42.060.F.5 Same as permit	No unique list of requirements.	3-3.5 Same as permit
6	Runoff Treatment	1.2.8 Core Req. # 8 Water Quality	Chapter 2, Same as permit	3.5.6 Same as permit	14.42.060.F.6 Same as permit	No unique list of requirements.	3-3.6 Same as permit

Approaches to Satisfying Permit's Minimum Requirements (Continued)

Minimum Requirement No.	Requirement in Permit	King County Surface Water Design Manual, 2005	City of Olympia Stormwater Manual	City of Tacoma 2003 Surface Water Management Manual	City of Bellingham Municipal Code 14.42.060 - Approval Standards 1995	Snohomish County Various Documents	Washington State Department of Transportation 2006 Highway Runoff Manual
7	Flow Control	1.2.3 Core Req. #3 - Flow Control	Chapter 2, Same as permit	3.5.7 Same as permit	14.42.060.F.7 Same as permit	No unique list of requirements.	3-3.7 Same as permit
8	Wetlands Protection	No specific requirement; uses Reference 5 Wetland Hydrology Protection Guideline ECOLOGY Guide Sheet 2B: Guidelines for Protection from Adverse Impacts of Modified Runoff Quantities Discharged to Wetlands.	Chapter 2, Same as permit	3.5.8 Same as permit	14.42.060.F.8 Same as permit	No unique list of requirements.	3-3.8 Same as permit
9	Basin/Watershed Planning	No specific requirement; uses Appendix B --- Master Drainage Plan Objective Criteria and Components and Review Process.	Chapter 2, Same as permit	3.5.9 Same as permit	14.42.060.F.9 Same as permit	No unique list of requirements.	3-3.9 Same as permit
10	Operation and Maintenance	1.2.6 Core Req. # 6 Maintenance and Operations	Chapter 2, Same as permit	3.5.10 Same as permit	14.42.060.F.10 Same as permit	No unique list of requirements.	3-3.10 Same as permit

Telephone Interviews with Ed O'Brien, Department of Ecology

As part of the ordinance review process, Otak interviewed Ed O'Brien with the Department of Ecology via phone on Monday, July 2nd and Tuesday, July 17th regarding other ordinances and Manuals. Ed has provided much of the leadership in the development of the Ecology Manual. He indicates that to date there are no manuals which have been shown to be equivalent to the 2005 Ecology Manual.

The Department of Ecology has reviewed Washington Department of Transportation's Highway Runoff Manual (HRM) and has sent a letter to WSDOT entitled *Highway Runoff Manual Consistency Review* dated February 16, 2007. Three items are listed as needing revising, and eight other items are listed but they seem to be less critical than these three items. The three items are as follows:

1. For flow control, WSDOT may assume pasture if historic information indicates that the site was prairie prior to settlement. WSDOT currently requires that all sites be considered forested for existing conditions.
2. WSDOT should expand its list of conditions when Enhanced Treatment is required. Treatment for removal of metals is of prime concern.
3. WSDOT should expand its list of conditions when Oil Control Treatment is required in eastern Washington.

According to Ecology, the City of Tacoma design manual also falls short in a few areas. In particular, the manual cites the use of regional facilities without demonstrating that these facilities are effective in providing detention or water quality treatment. Also, they do not demonstrate that regional facilities provide sufficient levels of treatment to qualify as enhanced treatment.

Ecology is currently reviewing King County's 2005 Surface Water Design Manual to see whether it conforms to the 2005 Ecology Manual. Review is in progress but Mr. O'Brien indicates that there is some discrepancy between King County and Department of Ecology thresholds for providing enhanced treatment.

Mr. O'Brien indicates that it is important for each jurisdiction to focus on showing how it is complying with the Permit's Appendix 1.

The following sections highlight the methodologies used by each jurisdiction in their efforts to implement the minimum requirements.

King County

King County Ordinance No. 15052 references the 2005 King County Surface Water Design Manual (King County Manual). This ordinance was approved by King County for use November 5, 2004. The King County Manual states that it conforms to the Ecology Manual, but has not yet been approved by Ecology.

The King County Manual lists core requirements without directly referencing the Minimum Requirements shown in the Ecology Manual or in the permit:

- #1 --- Discharge at Natural Location *(Corresponds with Minimum Requirement #4, Preservation of Natural Drainage Systems and Outfalls)*
- #2 --- Offsite Analysis *(Does not correspond to a minimum requirement from the permit)*
- #3 --- Flow Control --- Detention facilities are designed using King County's continuous flow model KCTRS *(Corresponds with Minimum Requirement #7, Flow Control)*
- #4 --- Conveyance Systems – Provides detailed guidance which is not included in permit conditions. *(Does not correspond to a minimum requirement from the permit)*
- #5 --- Erosion and Sediment Control --- The King County Manual provides ESC standards in Appendix D of their design manual. *(Corresponds with Minimum Requirement #2, Construction Stormwater Pollution Prevention Plan)*
- #6 --- Maintenance and Operation --- King County Manual provides maintenance standards in Appendix A of their design manual. *(Corresponds with Minimum Requirement #9, Operations and Maintenance)*
- #7 --- Financial guarantees and liability *(Does not correspond to a minimum requirement from the permit)*
- #8 --- Water Quality Treatment --- Required for projects having 5,000 square feet or more of new pollution-generating impervious surface, or 35,000 square feet or more of new pollution-generating pervious surface, or redevelopment projects that would result in a total of 5,000 square feet or more of new and replaced pollution generating impervious surface. *(Corresponds with Minimum Requirement #6, Runoff Treatment)*

These core requirements differ from the permit requirements in that they do not include (as core requirements) Ecology's Minimum Requirement #3, Source Control of Pollution, Minimum Requirement #8, Wetlands Protection, Minimum Requirement #1, Preparation of Stormwater Site Plans, or Minimum Requirement #5, Onsite Stormwater Management. However, these items are addressed elsewhere in the King County Manual.

King County does include three requirements that are not part of Ecology's minimum requirements:

1. Core Requirement #2: Offsite Analysis
2. Core Requirement #4: Conveyance System
3. Core Requirement #7: Financial Guarantees and Liability

The King County Manual defines four water quality treatment levels:

1. Basic --- treatment system must remove 80 percent of total suspended solids
2. Enhanced Basic Water Quality --- Enhanced treatment is required for drainage waters having high concentration of metals and draining to fish bearing streams. Treatment system must remove copper and zinc.
3. Sensitive Lake Protection --- Treatment system must remove 50 percent of total phosphorus
4. Sphagnum Bog Protection --- Treatment system must remove 50 percent of total phosphorus, and 40 percent of the total nitrate plus nitrite. The system should maintain pH less than 6.5 and alkalinity of less than 10 mg per liter.

Key Elements of King County Manual

The King County Manual includes a map delineating flow control areas within the County:

- Basic Flow Control Areas use Level 1 Flow Control which requires that the 2-year and 10-year peak flows be matched for existing and proposed conditions. There are some exemptions if increases in flows are extremely small.
- Conservation Flow Control Areas use Level 2 Flow Control which requires that the 2-year and 10-year peak flows be matched for existing and proposed conditions. The designer also needs to match developed discharge durations to pre-developed **historic site** durations for the range of pre-developed discharge rates from 50 percent of the 2-year peak flow up to the full 50-year peak flow. The **historic conditions** are considered to be equivalent to pre-developed conditions.
- Flood Problem Flow Control Areas – Designer should use Level 3 Flow Control which requires application of Level 2 Flow Control criteria plus matching of 100-year peak flows. Designer may assume **existing conditions are equivalent to pre-developed conditions** when matching the 100-year peak flows.

The King County Manual includes a flow control exemption for projects discharging to large lakes and streams. Several conditions must exist.

- The receiving water body must be on the list of major streams and rivers.
- The flow path from the project site to edge of the 100-year floodplain must be no longer than a quarter mile.
- The conveyance system between the project site and the major receiving water will extend to the ordinary high water mark and will consist of manmade conveyance elements.
- The designer uses continuous flow modeling. King County Runoff Time Series (KCRTS) is the standard software for estimating runoff rates and volumes.

City of Tacoma

The City ordinance 12.08.090 - Stormwater Program Requirements references the City of Tacoma Surface Water Management Manual (January 2003) for design guidance. The ordinance code calls out the same minimum requirements shown in the Stormwater Permit.

Appendix 1b of the City's manual shows the water quality design storm as being 72 percent of the 2-year storm.

Volume 3, Section 2.1 specifies the use of an HSPF model for determining the water quality flows. In the absence of an available calibrated model, the Santa Barbara Urban Hydrograph (SBUH) model may be used to estimate water quality design volumes or rates.

For treatment, SBUH or a calibrated continuous flow model must be used to determine the inflow hydrograph for the treatment BMP.

For detention, use a continuous flow model if available. If a calibrated model is unavailable the SBUH method may be used with volume correction factors based on percent impervious cover for developed conditions.

The City of Tacoma has modeled their 2003 Surface Water Management Manual (SWMM) after the Ecology Manual. In doing so, they have also adopted the same minimum requirements listed in the Ecology Manual; with additional requirements for "Off-Site Analysis and Mitigation" and "Financial Liability." The Off-Site Analysis and Mitigation requires development projects that discharge stormwater off-site to assess potential impacts by performing a qualitative downstream analysis. The Financial Liability requirement is intended to ensure that development projects will have the financial resources to implement a stormwater management plan and avoid the City's liability.

City of Olympia

In Chapter 13.16.017 of the City ordinance, the *Drainage Design and Erosion Control Manual for Olympia*, 2005 Edition (the Manual) is adopted by reference. This Manual was developed for Thurston County and the cities of Olympia, Lacey and Tumwater. It is applicable to the urbanizing areas of Thurston County. The Manual was one of the first to be approved by the Washington Department of Ecology as being substantially equivalent to their 2001 Stormwater Management Manual for Western Washington, but it has not been approved as equivalent to the 2005 Ecology Manual.

The City of Olympia has adopted the 2005 Ecology manual minimum requirements in their Stormwater Manual. However, in Minimum Requirement #5 for onsite stormwater management the City provides more detail on easements and setbacks associated with all man-made and natural drainage facilities and conveyances. This is to ensure that the jurisdiction will be allowed access for inspection, maintenance, flood control, water quality monitoring and other activities. This includes a minimum 15-foot wide access easement for drainage facilities within a public right-of-way. Also, an interview with Ed O'Brien (R. Schottman 7/17/07) indicated that the City needs to be more specific regarding the need for enhanced treatment.

City of Bellingham

City of Bellingham Municipal Code Chapter 15.42 appears to use the Ecology Manual and permit language. It lists the same minimum requirements, but does have different thresholds for triggering the requirements. (See the Thresholds section of this report.)

A continuous flow model is to be used for detention design. The manual allows the use of the SBUH model with volume corrections for detention design if a calibrated continuous flow model is not available.

Snohomish County

Snohomish County Ordinance Section 30.63A.040 indicates that Snohomish County Drainage Manual contains technical guidance for complying with the stormwater ordinance. A document specifically labeled as the Snohomish County Drainage Manual does not appear to exist. In its place, the County uses the following documents:

- 1992 Stormwater Management Manual for the Puget Sound Basin as basis for design of water quality and detention structures.
- 1998 Snohomish County Addendum for additional design requirements.
- 2005 SMMWW Manual for its section on erosion control.
- Snohomish County Engineering Design and Development Standards (3rd Edition with 2004 revisions) provide guidance for construction of roads and bridges.

None of these documents specifically addresses the ten minimum requirements listed in the stormwater permit. The County is in the process of updating its ordinances to conform to more recent Ecology manuals.

Minimum Requirement Thresholds

Several of the jurisdictions reviewed have utilized the thresholds presented in the Ecology Manual. In some cases, these jurisdictions have adopted their own version of the requirements, or added thresholds that better address drainage issues germane to their geographical area. Since the Ecology Manual is essentially the standard bearer for jurisdictions in Western Washington that are required to comply with NPDES, this section provides a comparison of the Ecology Manual with the thresholds listed in the ordinances from these jurisdictions.

King County

The King County 2005 Surface Water Design Manual (King County Manual) has thresholds that determine if a project requires one of four drainage reviews. The type of drainage review that is required will determine what core (or minimum) requirements must be applied to a proposed project. The four types of drainage reviews are Small Project Drainage Review, Targeted Drainage Review, Full Drainage Review, and Large Project Drainage Review. The thresholds triggering these

drainage reviews are as follows:

1. **Small Project Drainage Review:** Single family residential projects and agricultural projects resulting in $\geq 2,000$ sf of new impervious surface, but do not exceed several more specific thresholds, the maximum of which is 70,000 sf of new impervious surface.
2. **Targeted Drainage Review:** Projects subject to this type of drainage review are small projects with site-specific or project-specific drainage concerns that must be addressed by a civil engineer. These projects are not subject to Full or Large Project Drainage Review and have one or more of the following characteristics:
 - a. Projects containing or adjacent to flood, erosion, or steep slope hazard area; or projects within a Critical Drainage Area; or projects proposing $\geq 7,000$ sf of land disturbing activity.
 - b. Projects that construct or modify a drainage pipe/ditch that is ≥ 12 inches or receives runoff from a drainage pipe/ditch ≥ 12 inches.
 - c. Redevelopment projects with $\geq \$100,000$ in improvements to a high-use site.
3. **Full Drainage Review:** All projects that result in $\geq 2,000$ sf of new impervious or $\geq 35,000$ sf of new pervious surface; or redevelopment projects with $\geq 5,000$ sf of new plus replaced impervious surface and whose valuation of proposed improvements (including interior improvements) exceeds 50% of the assessed value of existing site improvements.
4. **Large Project Drainage Review:** Projects that result in ≥ 50 acres of new impervious within a sub-basin or multiple sub-basins that are hydraulically connected; or within a critical aquifer recharge area.

Projects falling under the Small Project Drainage Review type are primarily required to include simplified BMPs/measures for flow control and erosion and sediment control. The core requirements that must be addressed for projects subject to a Targeted Drainage Review is dependent on the characteristics of the site that trigger one of the three categories. Otherwise, all of the core requirements and special requirements must be addressed for projects requiring a Full or Large Project Drainage Review.

King County also has requirements for projects associated with a flood hazard area or Critical Drainage Area. Critical Drainage Area is a land designation made by King County Department of Natural Resources and Parks due to drainage conditions that have been impaired by severe flooding or erosion, and pose a threat to the welfare of the surrounding community.

City of Tacoma

The City of Tacoma has modeled their 2003 Surface Water Management Manual (SWMM) after the Ecology Manual. In doing so, they have also adopted the same thresholds and minimum requirements as Ecology; however, an additional requirement for “Off-Site Analysis and Mitigation” pertains to all development projects that discharge stormwater off-site. In order to assess potential

off-site impacts, all projects are required to perform a qualitative downstream analysis. Projects creating 10,000 square feet or more of new impervious areas without providing detention are required to perform a quantitative analysis. Projects may be exempt from flow control requirements if there are geographic specific requirements applicable to the point of discharge, or stormwater discharges are neither diverted nor increased to a wetland. The results of this quantitative analysis may also be used to determine a fee that may be paid in-lieu of providing flow control. These analyses are elaborated in Volume 1, Section 4.1.3 of the Tacoma SWMM.

City of Olympia

The City of Olympia has adopted Ecology's minimum requirements and thresholds in their Stormwater Manual, but they have a few variations on the thresholds used to determine minimum requirements applicable to redevelopments. If the value of the proposed improvements associated with a redevelopment project—including interior improvements—exceeds 25% of the assessed value of the existing site improvements, with a minimum of \$500,000 they are required to comply with Minimum Requirements #1 through #10 of the Ecology Manual.

Olympia has also included a separate flow chart to indicate thresholds that trigger the minimum requirements specific to road redevelopment. Minimum Requirements #1 through #10 must be applied if the new plus replaced impervious surfaces exceed 50% of existing driving lanes, curbs, sidewalks, bike paths, and shoulders with the project limits or if the estimated cost exceeds \$500,000, excluding engineering, contingency, and stormwater storage/treatment costs.

City of Bellingham

The City of Bellingham Municipal Code (BMC) requires all new developments needing a building permit or having a land disturbance greater than 500 square feet to implement a Construction Stormwater Pollution Prevention Plan (SWPPP)(Minimum Requirement #2). The BMC requirements are more stringent if the project site lies within the Lake Whatcom Watershed. The BMC has adopted Ecology's minimum requirements, but there are a few variations in the thresholds triggering the minimum requirements, including:

- Subdivisions or lots created from a subdivision, that contains two or fewer lots and is not likely to exceed the land disturbance and/or impervious thresholds from future property development are required to comply with Minimum Requirements #1 through #5, but a subdivision containing more lots than two must comply with all ten minimum requirements.
- Other development that is determined by the Public Works Director to contain a significant risk for the degradation of stormwater must comply with Minimum Requirements #1 through #5.
- A new development or redevelopment that includes one acre or more of land-disturbing activity must comply with Minimum Requirements #1 through #10.

Snohomish County

Snohomish County refers to the Washington State Department of Ecology's 1992 Stormwater

Management Manual for the Puget Sound Basin in conjunction with the Snohomish County addendum for design guidance. They have not yet adopted provisions related to the new permit or the Ecology Manual.

LID Approaches

This portion of the memo summarizes a review of existing ordinances and guidelines involving Low Impact Development (LID) approaches used by various jurisdictions in Western Washington and Oregon. NPDES stormwater regulations state that the jurisdictions must allow techniques such as LID technology to improve water quality to the “maximum extent possible”. The definition of LID according to the NPDES Phase I Permit states:

Low Impact Development (LID) means a stormwater management and land development strategy applied at the parcel and subdivision scale that emphasizes conservation and use of on-site natural features integrated with engineered, small-scale hydrologic controls to more closely mimic pre-development hydrologic functions.

LID is a relatively new engineering design approach for stormwater management in an attempt to maintain or enhance the pre-development hydrologic flow of an urban or developing watershed. As stormwater regulations become more stringent, the need to finance the high capital cost of stormwater infrastructure and meet National Pollutant Discharge Elimination Permit System (NPDES) requirements increases the community’s burden. The LID approach offers an environmentally sound and economically sustainable approach to address many stormwater management needs.

Example LIDs:

- Porous/permeable pavement
- Porous concrete
- Rain gardens
- Bioretention planter box
- Roadside bioretention swales
- Traffic island bioretention cell
- Vegetated roofs
- Rainwater harvesting
- Reverse slope sidewalks
- Bioretention
- Dispersion

Several jurisdictions in Western Washington, including Washington State Department of Ecology, refer to the *Low Impact Development Technical Guidance Manual for Puget Sound* (LID Manual) for more detailed design guidance.

Washington State Department of Ecology (Ecology)

Ecology identifies seven categories of LID techniques in Appendix III-C of the *2005 Stormwater Manual for Western Washington*. These categories include: permeable pavements, dispersion, vegetated roofs, rainwater harvesting, reverse slope sidewalks, minimal excavation foundations, and bioretention areas. Proper implementation of these techniques by new developments is awarded flow control credits towards meeting Minimum Requirement #7.

Ecology refers to the LID Manual for more detailed design guidance. The LID Manual was published by the Puget Sound Action Team and the Washington State University Cooperative Extension.

King County, Washington

King County has developed new LID-type stormwater code that has been added to the *2005 Surface Water Design Manual*. Although this new code is considered LID practices by King County, they note that they are currently calling these practices “flow control BMPs”. These BMPs emphasize infiltration and dispersion to control and treat stormwater runoff at the source.

City of Tacoma, Washington

The Tacoma Municipal Code (TMC) 12.08.560 allows developments that properly implement LID strategies to reduce monthly surface water fees by one category. However, Tacoma’s *Surface Water Management Manual* (January 2003) does not directly address LID as a strategy. The City’s manual does have standards for engineered source control BMPs and flow control BMPs that are comparable to LIDs strategies. No other direct references to LIDs could be found in either the *Surface Water Management Manual* or the City’s website.

City of Olympia, Washington

The City of Olympia Stormwater Manual Volume III does not directly mention any guidance for implementation of LIDs. However, Chapter 2 of the *City of Olympia Comprehensive Plan* includes at least one goal to adopt LID regulations within designated sensitive drainage basins. The City’s Stormwater Manual includes guidance for BMPs which may fit the definition of LIDs according to other local jurisdictions. Olympia identifies BMPs such as “Downspout Dispersion Systems”, infiltration basins, and infiltration trenches which can be considered LIDs.

City of Bellingham, Washington

The LID Manual may be used to design stormwater BMPs within the city limits of Bellingham, but the designs must meet the City’s general design standards (15.42.050.B.2 -General Requirements). The City of Bellingham Municipal Code (BMC) uses LIDs and “on-site stormwater management” interchangeably in several of their ordinances and refers to the Ecology Manual for design guidance

(15.42.060).

BMC requires projects to employ “onsite stormwater management BMPs” to the maximum extent possible according to BMC 15.42.060.B.5. In BMC 15.42.070.A.2(c) the City essentially places the responsibility for maintenance of LIDs on the subject property in accordance with the conditions of approval, unless the City has accepted maintenance responsibility in writing. The BMC does not allow stormwater BMPs in wetland buffers, but does make an exception for locating LIDs within the outer 25 percent of a Category III or IV wetland. There is no direct mention of LIDs in the City’s *Stormwater Management Handbook* from the Department of Public Works, but there is discussion of engineered source control BMPs that can also be considered LIDs. The *Draft Shoreline Master Program* (4/26/07) requires LIDs whenever feasible, and refers to BMC 15.42 for more specifics.

Snohomish County, Washington

In February of 2003, Snohomish County experimented with LID strategies by implementing the “Reduced Drainage Discharge Demonstration Program”, which was a program created to encourage developers to demonstrate innovative design and development techniques that take measures to reduce stormwater runoff beyond the requirements of the County code. This program expired three years after it was implemented, and is therefore no longer in effect.

In February 2006, Snohomish County adopted code 30.33A.150(A), which requires developers to incorporate LID strategies for fully contained communities (FCC). An FCC is essentially a master planned community with commercial, residential and public spaces. In July of 2006, the County followed that up by adopting the Puget Sound Action Team’s LID Manual as their official guidance manual for implementing LID strategies.

City of Portland, Oregon

The City of Portland seldom uses the term Low Impact Development (LID); however they have adopted several strategies that could be considered LIDs. Portland provides specifications and guidelines on Green Street technologies, source control BMPs, and flow control BMPs. The City’s *Stormwater Management Manual* (2005) provides some language that may apply to LID technologies, such as the use of green approaches for new developments to improve water quality to the maximum extent practicable.

Portland developed a Sustainable Stormwater Management Program that provides design and technical assistance to projects implementing sustainable stormwater management in the public rights-of-way. This program includes the implementation and evaluation of demonstration projects and promotes projects that mimic natural systems. This program, referred to as the *Standard Details for Vegetated Stormwater Facilities in the Public Right of Way*, has led to the development of green street details and specifications for developments requiring stormwater improvements in the public rights-of-way. Green street designs comply with NPDES permitting requirements by allowing the implementation of vegetated facilities to manage stormwater runoff at the source. Some of these

designs include swales, planters, and curb extensions.

Methods for Computing Conveyance Capacities

Each jurisdiction uses a different method to perform conveyance computations when sizing pipes, culverts, outfall and other hydraulic structures. Some use the uniform flow method which relies on the application of Mannings Formula, while others use backwater calculations when determining whether system overflow will occur. The second approach depends upon the definition of a tailwater elevation at the downstream end of the conveyance system. The following sections summarize the various approaches.

King County

Reference: 2005 King County Washington Surface Water Design Manual, Core requirement #4: Conveyance systems.

Compliance Criteria

The designer may use the backwater analysis method to determine whether the hydraulic grade line stays below the road surface elevation.

Pipe systems

Pipe systems must convey and contain the 25-year peak flow. They may overtop for larger events, but these larger events must not create or aggravate a severe flooding problem.

Culverts

Culverts must convey, at a minimum, the 25-year flow, and headwater surface elevation must conform to criteria in Section 4.3.1:

- For culverts 18 inches in diameter or less, the maximum allowable headwater depth above the invert shall not exceed 2 times the pipe diameter or arch-culvert rise
- For culverts larger than 18 inches in diameter, the maximum headwater depth above the invert shall not exceed 1.5 times pipe diameter or arch-culvert rise
- Maximum headwater elevation for the design flow shall be below any road or parking lot subgrade.

Culverts must convey as much of the 100-year peak flow as is necessary to preclude creating or aggravating a severe flooding problem. Overflow must discharge at a natural location.

Ditches and Channels

Ditches and channels must provide sufficient capacity to convey and contain at minimum the 25-year peak flow. They must also contain as much of the 100-year flow as to preclude potential flooding problems.

Bridges

Bridges must accommodate the 100-year peak flow as specified in Section 4.3.3 and in accordance with floodplain development standards in KCC21A.24.

King County has separate requirements for existing and proposed systems.

Runoff Computation Methods --- Table 3.2**1. Tributary Areas less than 10 acres**

- Rational Method – Required for undetained areas, and okay for detained areas if no storage routing is performed.
- TR55 or SBUH --- Not acceptable.
- KCRTS or HSPF Continuous Flow Modeling – Okay if majority of tributary area is detained, and 15-minute time steps with flow path adjustments (length and slope of longest path) are used.

2. Tributary Areas Greater than 10 Acres

- Rational Method – Okay if no storage routing is performed.
- TR55 SBUH --- Okay if no storage routing is performed.
- KCRTS or HSPF Continuous Flow Modeling – Okay if 15-minute time steps with flow path adjustments (length and slope of longest path) are used. Storage routing is allowed.

City of Tacoma

The City of Tacoma provides conveyance system design standards in their *Surface Water Management Manual*, which was revised in 2003 to comply with the National Pollution Discharge Elimination System (NPDES) permit. Conveyance design standards are contained in Chapter 4 of Volume III of the City's manual.

Section 4.4 contains the requirements for the conveyance system design. All public and private conveyance systems less than 24 inches in diameter are required to convey the 10-year, 24-hour peak flow rate without surcharging. Public and private systems greater than or equal to 24 inches in diameter are required to convey the 25-year, 24-hour peak flow rate without surcharging. Culverts must be designed to convey the 25-year, 24-hour peak flow rate without submerging the culvert inlet. The City allows the use of the Rational Method, Santa Barbara Urban Hydrograph (SBUH), or Western Washington Hydrology Manual (WWHM) to compute the design flows according to Section 4.5.

Section 4.6 contains the requirements for the conveyance capacity analysis. The City requires the uniform flow analysis using Mannings formula to be used for preliminary design and analysis. If the depth of flow for the 10-year or 25-year events is found to be greater than 90 percent of pipe inside diameter, then a backwater analysis must be performed. The backwater analysis for the 25-year event must predict a water surface elevation at least 0.5 feet below the rims of all manholes or catch basins. Surcharging of the system may occur for the 100-year event; however, the flow depth at the deepest point must be less than 4 inches, and the flow must not extend beyond half the lane width in the outside lane of the roadway.

City of Olympia

The City of Olympia provides conveyance system design standards in Volume 1, Appendix I-F of their *Stormwater Manual*, which was revised in January of 2005.

Design Event

The 25-year, 24-hour event is to be used for all roads except arterials, major collectors and other roads. If the local permitting authority determines that vital service interruption would be unacceptable, then the 100-year event applies. Culverts and bridges over natural channels must convey the 100-year event without overtopping.

Methodology

A continuous simulation model or an event-based model such as the Santa Barbara Urban Hydrograph model, or the Rational Method with the localized Intensity-Duration Frequency (IDF) curves in Figure F-1 may be used. For the design event, the designer must ensure:

- a minimum 12-foot wide dry travel lane, except at sag/sump points and
- a maximum 0.5 ft ponding depth at any low (sag/sump) point

Culverts

For culverts, the predicted water surface elevation during the design event shall be below the top of the channel. The maximum design water surface for culverts that convey streams shall be below the culvert crown.

City of Bellingham

Conveyance system designs within the jurisdiction of the City of Bellingham are required to comply with the *Stormwater Management Handbook* revised November 10, 1997. The *Handbook* cites City of Bellingham Municipal Code (BMC) chapters 15.42, 15.16, 16.50, and 16.60. It also Ecology's *Stormwater Management Manual for the Puget Sound Basin (Technical Manual)* for portions of conveyance design. We assume that the citation references the 1992 version of the *Technical Manual*.

According to Section 2.4.2 of the *Handbook*, developments involving less than 10 acres must design conveyance capacity based on peak flows calculated using the Rational Method, while those greater than 10 acres may use the Santa Barbara Urban Hydrograph (SBUH) Method. Trunklines and arterial stormwater conveyance systems must be designed using the 25-year, 24-hour storm event, while minor conveyance systems are only required to use the 10-year, 24-hour storm event. The hydraulic response of conveyance system designs must be modeled to determine how well the system will convey a 100-year storm event.

Snohomish County

The ordinance provides detailed descriptions of design components, but also references several types of design guidance. Drainage facilities shall be designed and constructed in accordance with requirements of County Code 30.63A SCC, using the county's Engineering Design and Development Standards (EDDS) 2004 and the WSDOT Hydraulics Manual, in that order.

Conveyance is discussed in County Code 30.63.200 SCC. In summary:

- Conveyance systems shall accommodate the peak discharge from the 100-year, 24-hour design storm.
- A conveyance system is considered adequate if the peak discharge and maximum water level is contained with drainage easements or within existing conveyance systems. Conveyance system may overflow or be surcharged if:
 - Stormwater runoff does not inundate the traveled portion of public or private road.
 - No portion of a building will be flooded.

Methodology

Conveyance system computation methodology is based on drainage areas:

- Areas less than 25-acres --- Computation standard is the Rational Method.
- Areas greater than 25-acres --- Minimum computation shall be the SCS TR-55 method or equivalent as approved by the director.

Engineering Design and Development Standards (EDDS, 2004)

The hydraulic flow capacity should be estimated based on Manning's Formula. Our review failed to find a hydrology section in the EDDS.

For open channels, the EDDS Section 5-03 entitled Conveyance Systems Open Channels should be used. Hydraulic capacity criteria depend upon flow rates:

- Flowrate less than 10 cfs --- Freeboard should be greater than or equal to 0.5 ft.
- Flowrate greater than or equal to 10 cfs --- Freeboard should be greater than or equal to 1.0 ft.

The EDDS provides specific Mannings n values based on materials in channel bottom.

EDDS Section 5.04 entitled Conveyance Systems Pipes discusses culvert design. For culverts, the allowable headwater depth must be less than:

- 2.0 times the height of the culvert for 18-inches or less,
- 1.5 times the culvert height for culverts greater than 18-inches, or

- 1.0 times the height of the culvert for bottomless culverts.

Backwater calculations were not discussed in the Snohomish County guidance documents.

Clean Water Services (Washington County, OR)

In Resolution & Order (R&O) 07-20 dated April 14, 2007, CWS adopted revisions to their *Design and Construction Standards*. They assume complete build-out conditions using the 25-year, 24-hour and 100-year, 24-hour flow events.

Flow Determination Methodology

Rational Method

The rational method should be used for drainage areas less than one acre. Time of concentration shall be five minutes when times are calculated to be less than five minutes. CWS uses its own IDF table, which is included as part of Standard Drawing 1275.

Santa Barbara Urban Hydrology Method

The 24-hour storm with Type 1A rainfall distribution, and TR-55 curve numbers should be used. Soil types from NRCS soil survey for Washington County may be referenced.

TR-55 Method

TR-55 method uses the same assumptions as Santa Barbara Urban Hydrograph Method.

Stormwater Management Model (SWMM)

The SWMM hydrology model may be used on medium to large projects when computing runoff volumes for conveyance.

Design Criteria

- A minimum of one foot of freeboard is required between the hydraulic grade line and top of structure, or finish grade above pipe for 25-year post development peak rate of runoff.
- A structure shall not cause flooding in portions of a habitable facility.
- Flows in streets shall not run more than four inches deep against the curb or extend more than two feet into the motor vehicle travel lane.
- Flow line for 100-year event shall not go through existing building.
- Open channel systems shall provide a minimum of one foot of freeboard from bank full.
- Maximum overland distance for sheet flow used in calculations shall be 50 feet.

Culvert Design

- For culverts less than 18 inches in diameter, headwater depth shall be less than 2.0 times culvert diameter

- For culverts greater than 18 inches in diameter, headwater depth shall be less than 1.5 times culvert diameter
- Maximum headwater elevation of a design storm event for new culverts shall be a least one foot lower than the road or parking lot subgrade.